MEMORANDUM

To: Amy Hambrick, U.S. EPA, Sector Policies and Programs Division/Natural Resources and Commerce Group

From: Eastern Research Group, Inc.

Date: January 2011

Subject: Revised Analysis of Beyond the Maximum Achievable Control Technology (MACT) Floor Controls for Existing SSI Units

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1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA), under section 129 of the Clean Air Act (CAA), is required to regulate emissions of nine pollutants from existing sewage sludge incineration (SSI) units. The nine pollutants are: hydrogen chloride (HCl), carbon monoxide (CO), lead (Pb), cadmium (Cd), mercury (Hg), particulate matter (PM), total mass basis dioxins/furans (TMB PCDD/PCDF) and toxic equivalency basis dioxin/furans (TEQ PCDD/PCDF), nitrogen oxides (NO_x), and sulfur dioxide (SO_2). The CAA requires EPA to determine the maximum achievable control technology (MACT) for each subcategory of sources.

To do so, EPA must first determine the minimum stringency "floor" requirements. A previous memorandum documents the MACT floor analysis for SSI units.[1]

EPA must also examine more stringent "beyond-the-floor" (BTF) controls to determine MACT. Unlike the minimum stringency requirements of the floor, EPA must consider various impacts of the more stringent regulatory options such as costs and emissions reductions in determining whether MACT standards are to reflect BTF requirements. This memorandum describes the cost and emissions reductions for existing SSI units achieved by applying BTF controls.

Tables 1-1A and 1-1B summarize the costs and emissions reduction calculated for the MACT floor level of control and each of the analyzed BTF controls. Table 1-1A shows the cost and 'actual' emission reductions of the MACT floor and the BTF options, and Table 1-1B shows the cost and 'potential' emission reductions of the MACT floor and the BTF options applied only to larger entities. As described in further detail in the baseline emissions memo[2], 'actual' emissions are based on calculations using actual sludge feed rates, whereas 'potential' emissions are based on calculations using sludge capacities.

Table 1-1. Summary of Cost and Emissions Reductions (tpy) for BTF Controls Analyzed

A. Costs and Emission Reductions Based on 'Actual' Sludge Usage

Controls Analyzed	TCI ($)	TAC ($/yr)	Baseline Emissions and Incremental Emission Reductions (tons/year)									
			Cd	CO	HCl	Pb	Hg	NO_x	PM	SO_2	PCDD/PCDF (mass)	PCDD/PCDF (TEQ)
Baseline Emissions	-	-	0.9096	8501	28.15	2.3717	0.8942	2380	332.85	702.4	0.000006	0.0000004
1 - MACT Floor	$55,047,913	$17,766,866	0.50	0	18.52	1.21	0.0022	6.8	58.1	431.5	0	0
2 - MACT Floor + AB for MH units	$155,314,172	$46,097,268	0.499	6865	18.52	1.21	0.002	6.783	58.1	431.5	0	0
3 - MACT Floor + AB and ACI/FF for MH units	$486,470,566	$138,260,525	0.870	6865	18.52	2.28	0.667	6.783	299.9	431.5	0.00000495	0.000000332

B. Costs and Emission Reductions Based on 'Potential' Sludge Capacity

Controls Analyzed	TCI ($)	TAC ($/yr)	Baseline Emissions and Incremental Emission Reductions (tons/year)									
			Cd	CO	HCl	Pb	Hg	NO_x	PM	SO_2	PCDD/ PCDF (mass)	PCDD/P CDF (TEQ)
Baseline Emissions	-	-	1.15	11576	43.34	3.0744	1.2099	3277	444.79	1077.5	0.000009	0.0000006
1 - MACT Floor	$55,047,913	$17,766,866	0.60	0	29.94	1.50	0.0025	15.7	70	697.8	0	0
2 - MACT Floor + AB for MH units	$155,314,172	$46,097,268	0.60	9354	29.94	1.50	0.00	15.72	69.57	698	0	0
3 - MACT Floor + AB and ACI/FF for MH units	$486,470,566	$138,260,525	1.098	9354	29.94	2.94	0.891	15.72	395.7	697.8	0.00000662	0.000000444

The tables show three control scenarios analyzed for SSI units:

- Combination 1 is the MACT floor level of control for the two subcategories developed for existing multiple hearth (MH) units and fluidized bed (FB) units.

- Combination 2 is the MACT Floor level of control, with the addition of afterburner retrofits for additional CO emissions reduction from MH units not already having an afterburner.

- Combination 3 is the MACT Floor level of control, afterburner retrofits for MH units not already having them, and the addition of activated carbon injection (ACI) in combination with a fabric filter for MH units for additional Hg and PCDD/PCDF emissions reduction.

Section 2.0 discusses the selection of more stringent controls or emissions levels than the floor level reviewed for this analysis. Section 3.0 discusses the methodology used to estimate costs and emissions reductions of the more stringent controls and Section 4.0 summarizes the controls selected for the BTF analysis.

2.0 SELECTION OF MORE STRINGENT CONTROLS

The MACT floor analysis for existing sources results in emissions levels that each existing SSI unit is required to meet. The costs and emissions reduction of the MACT floor requirements were estimated using the following assumptions: (1) units that needed to meet the MACT floor for Cd, Pb, and PM would add a venturi scrubber (if they did not have one at proposal) or wet electrostatic precipitator (WESP), (2) units that needed to meet the MACT floor for HCl, and SO_2 would add a packed bed scrubber (PBS), and (3) units that needed to meet the MACT floor for NO_x would add selective non-catalytic reduction (SNCR). All FB and MH units were determined to meet the floor level of control for Hg, PCDD/PCDF, and CO, and no additional control was necessary.

The control technologies that were costed to achieve the MACT floor levels for PM, Cd, Pb, HCl, SO_2, and NO_x are the most effective controls available for SSIs to reduce these pollutants, given the high moisture content of SSI flue gas streams. The control effectiveness of the control devices used in the MACT floor analyses are discussed in the MACT floor cost and emission reductions memorandum.[3] Since not every SSI unit was determined to need WESP, PBS, or SNCR to achieve the MACT floor level of control or operated them currently (i.e., the baseline level of control), these controls were analyzed for the entire SSI source category, which would require all units that did not have these controls at baseline or for meeting the MACT floors to add these controls.

For other combustion sources, carbon injection in combination with a FF has proven to be highly effective in removing Hg. However, for high moisture flue gas streams, such as emitted from SSI units, the use of FFs is problematic due to plugging/fouling. In order to use carbon injection with a FF with high moisture streams, a waste heat boiler, RTO, or afterburner is necessary to maintain a high enough temperature to keep the stream above the dew point prior to sending the stream to the FF. This control combination was costed as the beyond-the-floor control for Hg. Additional equipment may also be necessary to reduce the temperature of the flue gas to prevent damage to the fabric filter bags. Sufficient information was not collected to estimate this cost; for this cost scenario, costs will be underestimated. Data gathered by EPA indicates that ACI applied to combustion sources with particulate control can achieve 85-95 percent reduction of Hg, depending on the type of particulate control, with higher reductions achieved by units with fabric filters and lower reductions achieved by units with electrostatic precipitators. Based on efficiencies demonstrated in other source categories and in EPA studies, a beyond-the-floor reduction of 90 percent for Hg was used for carbon injection in combination with FF applied to existing MH unit controls. Previous EPA studies also show that PCDD/PCDF can be reduced by as much as 98 percent using ACI and FF together.

For CO, the MACT floor level of control for existing MH units is 3,800 ppmvd, corrected to 7 percent oxygen. An add-on combustion device, such as an afterburner or thermal oxidizer was analyzed as a more stringent control device that could be applied to SSI units. CO emissions data were collected from nine MH SSI units as part of the data collection efforts supporting the development of emissions standards for SSI units. Table 2-1 summarizes the average CO concentration levels from these units.[4] The table is grouped into three classes of SSI's: (1) units that do not use any combustion controls, (2) units that use an on-hearth afterburner, and (3) units that use either a detached afterburner or thermal oxidizer, or use FGR in combination with an on-hearth afterburner.

Table 2-1. Summary of Average CO Emissions Collected From MH Units

Classes	Facility	Location	Unit ID	Average CO emission level (ppmvd @ 7% O_2)
Uncontrolled	Boat Harbor	VA	1	3,761
On-hearth afterburner	Seneca	MN	1	1,323
			2	853
	Central Contra Costa	CA	1	905
			2	752
Detached afterburner, thermal oxidizer, or on-hearth afterburner with flue gas recirculation	Columbia Metro	SC	1	63
	Mountainview	NJ	2	39
	Upper Blackstone	MA	1	28
			3	59

On-hearth afterburners are the top hearth of a MH unit that has been re-designed so that sludge is rerouted to the second hearth. Retrofitting the MH unit with an on-hearth afterburner may require modifications to downstream air pollution control systems due to higher temperatures and larger volumes of exhaust gases.[5] While there will be reductions in CO and total hydrocarbon (THC) emissions, the reductions may be limited due to low temperature and limited residence time of the gas in the afterburner stage. The use of FGR in combination with an on-hearth afterburner shows significantly lower emissions levels than just using an on-hearth afterburner. However, this may be a generalization because only one data point for this control combination was reviewed. Additionally, performance of FGR is often influenced by site specific parameters which may not be generalized to the entire subcategory.

Table 2-1 shows that MH units using an add-on afterburner or thermal oxidizer can achieve CO emission levels less than 100 ppmv. The Clean Water Act (CWA) "503 Rule" [40 CFR Part 503] limits sewage sludge incinerators to 100 ppm THC as propane, dry basis, corrected to 7% oxygen, averaged for 30 days. The CWA 503 Rule allows substitution of 100 ppm CO dry basis, corrected to 7% oxygen for the THC originally required. The 100 ppm CO level was selected because this level was determined to be a level that would be indicative of the THC concentration below 100 ppm. This allows the use of a lower cost, easier to maintain CO monitor in place of the difficult to keep online THC monitor. To be consistent with the CWA 503 regulations for disposal of sewage sludge for the beyond-the-floor calculation, a value of 100 ppmv was used as the emission level that a MH unit with an afterburner could achieve. Beyond-the-floor controls were also evaluated for existing FB units. The proposed SSI MACT floor CO level for existing FB units (56 ppmvd, corrected to 7 percent oxygen) is well below the 100 ppmvd emission level of the CWA 503 rule. The application of an afterburner was determined not to achieve appreciable CO reduction form the proposed limit for the cost incurred. Therefore, no beyond-the-floor CO limit was considered for the FB subcategory.

3.0 METHODOLOGY USED TO ESTIMATE COST AND EMISSIONS REDUCTIONS

The methodology used to calculate costs and emissions reductions from applying the more stringent controls followed the procedures discussed in the SSI Cost memorandum.[3] As described above, if a unit already had an afterburner, ACI, PBS, FF, or WESP, or needed one of these to meet the MACT floor limits, no additional costs were calculated for the beyond-the-floor analysis. Otherwise, these controls were costed out for the unit as appropriate. The algorithms, inputs for algorithms, and testing, monitoring, recordkeeping, and reporting costs calculations are the same as conducted for the MACT floor and are discussed in detail in the MACT floor cost and emissions reductions memorandum. However, ACI/FF combination was not required for units to meet the MACT floor, so the ACI and FF cost algorithms are included with this memo, as Attachments A and B. Attachment C presents the inputs used for these algorithms.

Emissions reductions from application of the beyond-the-floor controls relative to the MACT floor limits were calculated using the following procedure. First, the reduction efficiency of the beyond-the-floor control for each pollutant was applied to the uncontrolled concentration to determine the total reduction the control would achieve. The reduction from uncontrolled levels to the MACT floor limits was previously calculated for the MACT floor cost and emissions reduction analysis.[3] For each pollutant, the incremental reduction between the more stringent beyond-the-floor control and the MACT floor was calculated by subtracting the MACT floor emissions reductions from the reductions achieved by the more stringent control.

4.0 SELECTION OF REGULATORY OPTIONS

Tables 4-1 and 4-2 summarize the costs, emissions reductions, and incremental cost effectiveness of the controls analyzed in the BTF analysis, for the case where ‘actual’ emission reductions are considered (Table 4-1) and the case where ‘potential’ emission reductions are considered (Table 4-2). Further description of ‘actual’ emissions (based on actual sludge feed rates) and ‘potential’ emissions (based on unit sludge capacities) can be found in the baseline emissions memo.[2] The tables indicate that except for the afterburner, all of the controls applied result in a high incremental cost-effectiveness. Consequently, these controls, with the exception of activation carbon injection in combination with a FF for Hg control at MH units, were considered infeasible. Mercury is a high priority pollutant of interest, and additional control beyond the floor for Hg was analyzed for the proposed rule. Three different control combinations were therefore selected for the beyond-the-floor analysis: (1) MACT Floor control only, (2) MACT Floor control with the addition of afterburner retrofits for additional CO control for MH units not already having afterburners, and (3) MACT Floor control, afterburners for MH units not already having them, and ACI and FF for MH units for additional Hg and PCDD/PCDF control. The costs, total emissions reductions, and incremental cost effectiveness of the three control combinations are summarized in Table 4-3 (with ‘actual’ emissions) and Table 4-4 (with ‘potential’ emissions). Attachments D1 and D2 present the costs for each control combination and subcategory for each SSI unit. Attachments E1 through E7 present the emission reductions based on ‘actual’ sludge usage and supporting details for each beyond the floor control considered, and attachments F1-F7 present the emission reductions based on ‘potential’ sludge capacity and supporting details for each beyond the floor control considered.

REFERENCES

1. Revised MACT Floor Analysis for the Sewage Sludge Incinerator Source Category. Memorandum from Eastern Research Group to Amy Hambrick, U.S. Environmental Protection Agency. January 2011.
2. “Revised Estimation of Baseline Emissions From Existing Sewage Sludge Incineration Units” Memorandum from Eastern Research Group, Inc. to Amy Hambrick, U.S. Environmental Protection Agency. January 2011.
3. Revised Cost and Emissions Reduction of Complying with the MACT Floor for Existing SSI Units. Memorandum from Eastern Research Group to Amy Hambrick, U.S. Environmental Protection Agency. January 2011.
4. Facility, Unit, and Emissions Test Database for the Sewage Sludge Incineration Source Category. Memorandum from Eastern Research Group to Amy Hambrick, U.S. Environmental Protection Agency. June 2010.
5. A Comparison of Fluid Bed and Multiple Hearth Biosolids Incineration. Ky Dangtran, John Mullen, and Dale Mayrose. Paper presented at the 14th Annual Residuals and Sludge Management Conference. February 27-March 1, 2000, Boston MA.

TABLES AND ATTACHMENTS

Table 4: See BeyondTheFloorMemo_Table4.xlsx

4-1. Emissions Reductions and Costs by Control: 'Actual' Emission Reductions

4-2. Emissions Reductions and Costs by Control: 'Potential' Emission Reductions

4-3. Emissions Reductions and Costs by BTF Control Combination: 'Actual' Emission Reductions

4-4. Emissions Reductions and Costs by BTF Control Combination: 'Potential' Emission Reductions

Attachment A. Control Costs: Fabric Filter Algorithm for Incinerators
See BeyondTheFloorMemo_AttachA-D.xlsx

Attachment B. Control Costs: ACI Cost Algorithm for Incinerators
See BeyondTheFloorMemo_AttachA-D.xlsx

Attachment C. Inputs to BTF Analysis
See BeyondTheFloorMemo_AttachA-D.xlsx

Attachment D. Cost Details
See BeyondTheFloorMemo_AttachA-D.xlsx

D1. Fluidized Bed Sewage Sludge Incinerators

D2. Multiple Hearth Sewage Sludge Incinerators

Attachment E. Emission Reduction Details ('Actual')
See BeyondTheFloorMemo_AttachE.xlsx

E1. Emission Reductions for Each BTF Control Considered

E2. BTF Emissions for SNCR

E3. BTF Emissions for Afterburner Retrofit

E4. BTF Emissions for PBS

E5. BTF Emissions for WESP

E6. BTF Emissions for FF

E7. BTF Emissions for ACI/FF

Attachment F. Emission Reduction Details ('Potential')

See BeyondTheFloorMemo_AttachE.xlsx

F1. Emission Reductions for Each BTF Control Considered

F2. BTF Emissions for SNCR

F3. BTF Emissions for Afterburner Retrofit

F4. BTF Emissions for PBS

F5. BTF Emissions for WESP

F6. BTF Emissions for FF

F7. BTF Emissions for ACI/FF

Attachment G. Correspondence between EPA's testing and monitoring group and ERG regarding Hg control.